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Method For Perspective Adjustment and De-warping Between a Wide and Telephoto Lens

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1.	Title

Method For Perspective Adjustment and De-warping Between a Wide and Telephoto Lens

2.	Abstract

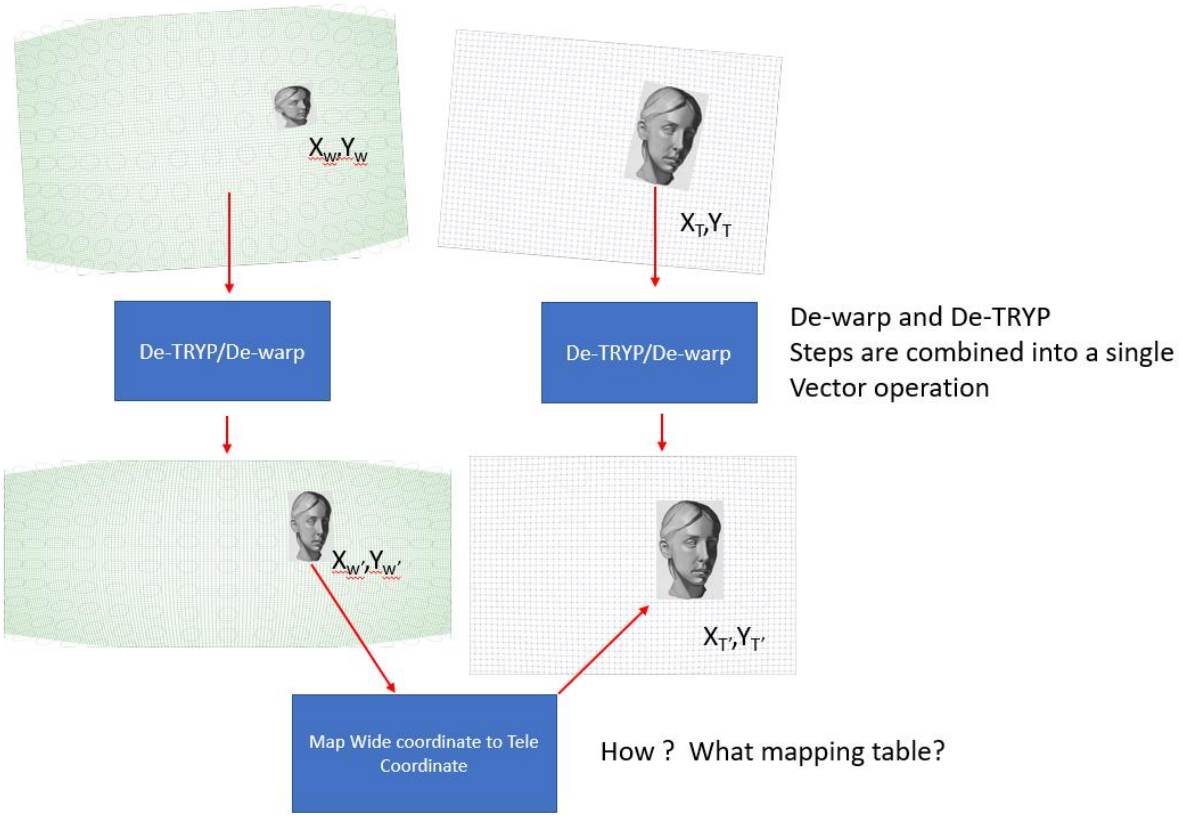
A single dot-matrix grid can be imaged from wide and telephoto lenses simultaneously. This grid is used as a calibration device during manufacturing. A software algorithm and implementation finds the true locations of each dot in space from the distorted image. Once the error between the true dot location and the imaged dot location is known, this error vector can be used to correct each image. Further, these dot locations in the uncorrected images can be used in a morphing algorithm to morph smoothly from one lens to another.

3.	Background:

A conferencing camera that uses both a wide and telephoto lens to optimally capture high quality images of people both near and far from the camera. Using two lenses has the benefit of extending the pixel limit of a sensor by using two sensors. The challenge is that electronically zooming in from the wide view into the telephoto view will present the viewer with two different perspective and the two lenses each have different distortions. This change from wide to telephoto and back again will be unnatural unless a suitable solution is provided. This disclosure solves this problem by providing a method for smoothly transitioning between the perspectives and different geometric distortions.

One challenge is precisely knowing the distortion of each lens. Another is knowing the mechanical alignment between the lens down to the pixel. Mechanical considerations are distance between the lenses, and the relative rotation of each lens in 3 dimensions.

There are well-known mathematical models and de-warping solutions for lens distortion. But these solutions are for single lens cameras and assume the viewer does not have in mind a correct de-warp image as a reference so an imperfect de-warp is sufficient. However, given the two lenses, the viewer now can potentially see two different views and one will look distorted relative to the other. The solution to this two lens problem is highly complex mathematically and will vary from lens to lens as manufactured lenses are not perfectly predictable.



6.	**Previous Solutions**:

Single Lens Distortion Correction (a.k.a calibration)

This approach is well known and widely implemented. But it does not account for the unique problems of a two lens solution.

A new calibration model of camera lens distortion, by Jianhua Wang∗, Fanhuai Shi, Jing Zhang, Yuncai Liu, Received 28 April 2006; received in revised form 9 February 2007; accepted 28 June 2007, the Journal of Pattern Recognition

D.C. Brown, *Close-range camera calibration*, Photogramm. Eng. 37 (8) (1971) 855–866.

Image Morphing – smoothly morph one picture into another

This technique is very useful but requires a human to transcribe source and destination features in each image. For a moving video sequence, this painstaking process requires special video editing software designed to aid the human designer. This is not suitable for a real-time video conference.

Image morphing is a technique to synthesize a fluid transformation from one image (source image) to another (destination image). Morphing has been wildly used in making visual effects. One of the most famous morphing example is Michael Jackson's "Black or White" MTV. The

morphing algorithm used to make this video has been described by Beier and Neely in their paper (*Feature-based Image Metamorphosis*, Thaddeus Beier and Shawn Neely, Computer Graphics, 2 July 1992).

Two Lens Stitching

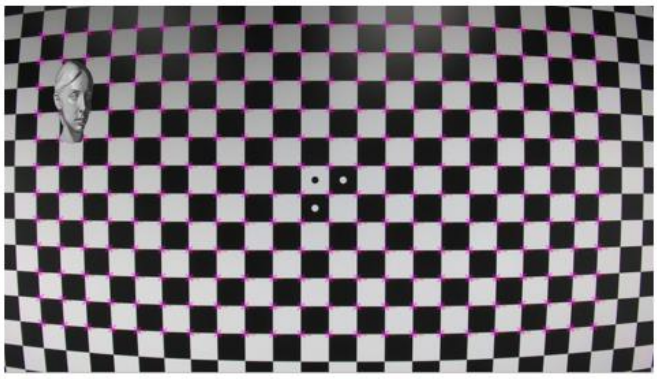
Huaitao Shi et al. describes a method that solves a two lens distortion problem. But his method requires object detection algorithms. These may be possible in a conference room situation, but these object detectors themselves prove to be a challenging problem.

Improved Parallax Image Stitching Algorithm Based on Feature Block, Huaitao Shi 1, Lei Guo 1, Shuai Tan 2, *, Gang Li 1, Jie Sun, Symmetry March 2019.

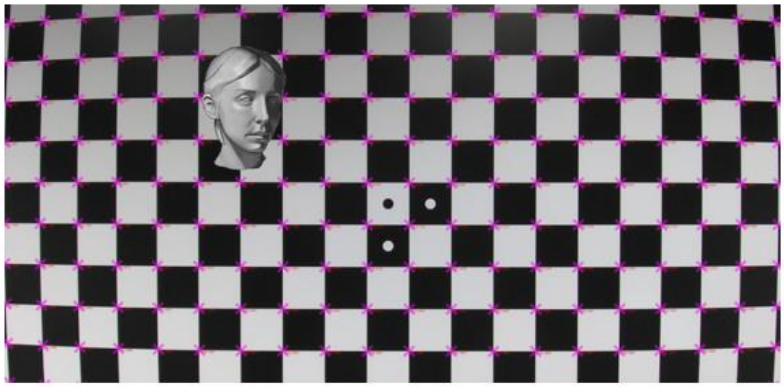
7.	**Description**

The same physical objects will look completely different from each lens. But we want to zoom into the face from the wide lens into the telephoto. This will look strange to the user if we do not solve the warping and position errors.

Wide Lens Geometric Distortion



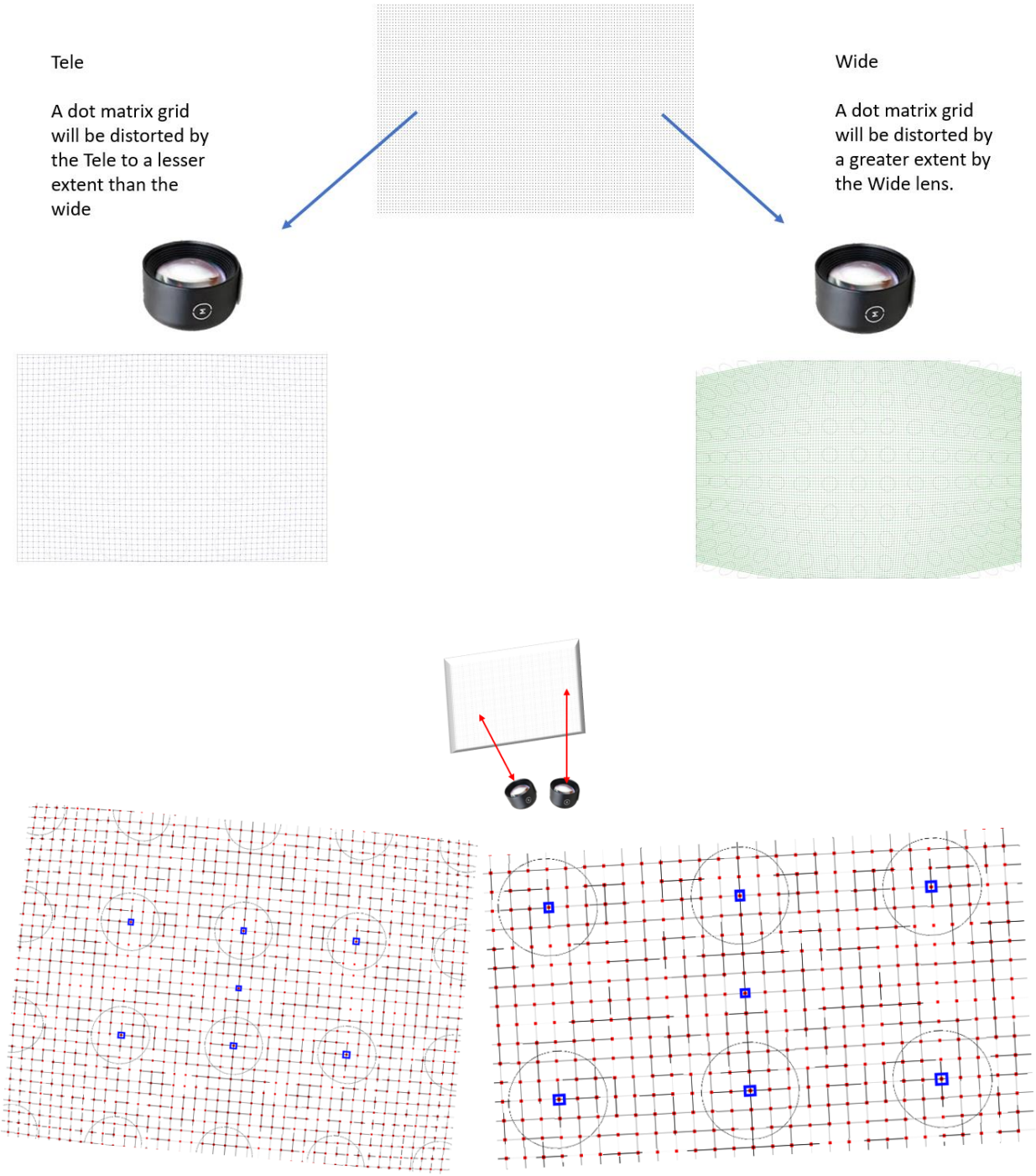
Tele Lens Geometric Distortion

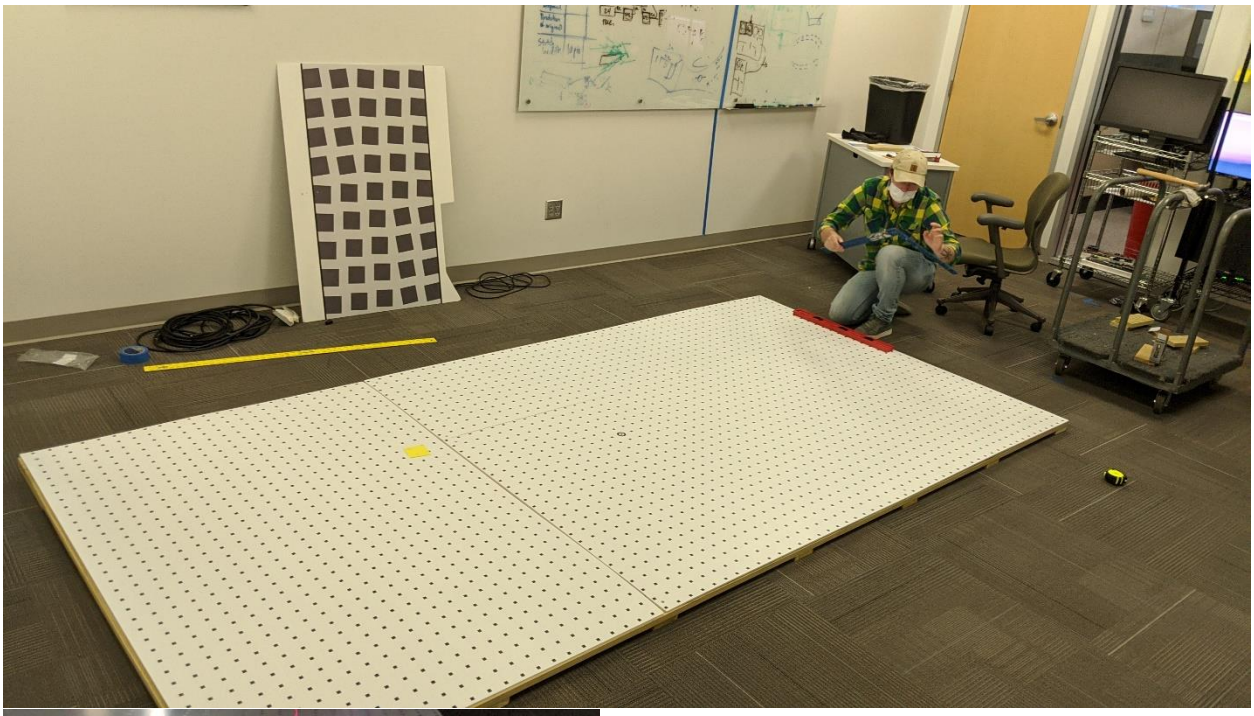


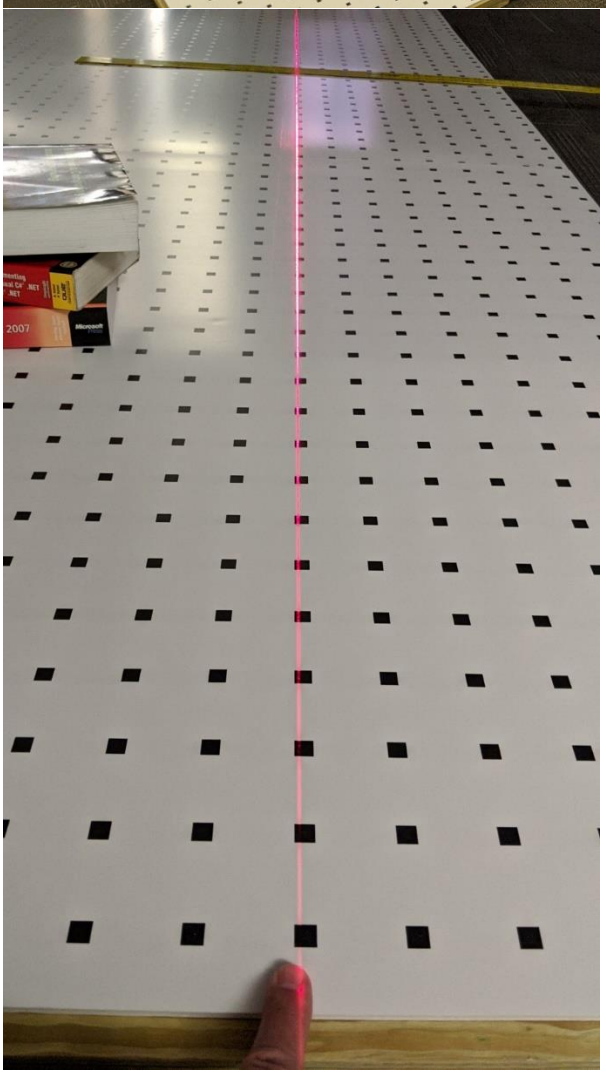
This solution uses a single dot-matrix grid which can be imaged from both lenses simultaneously. This grid is used as a calibration device during manufacturing.

A software algorithm and implementation was created to find the true locations of each dot in space from the distorted image. Once the error between the true dot location and the imaged dot location is known, this error vector can be used to correct each image.

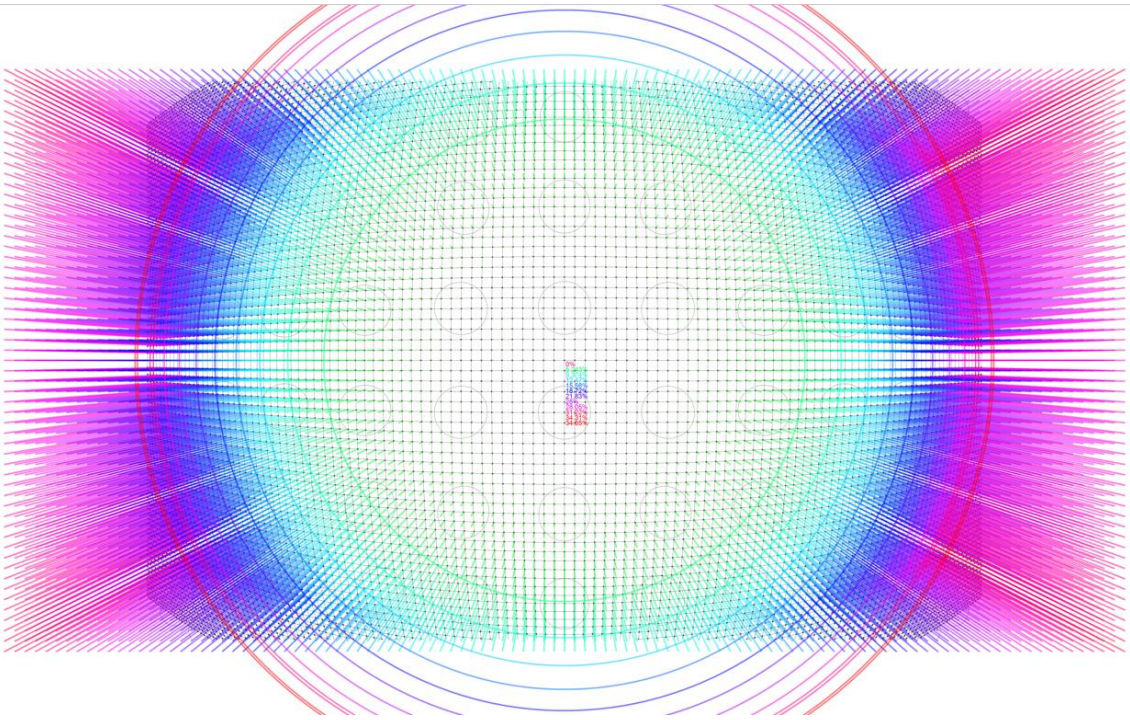
Further, these dot locations in the uncorrected images can be used in the morphing algorithm to morph smoothly from one lens to another.







A graphical depiction of the algorithm derived error vectors showing the true distortion of a wide lens:



A graphical depiction of the algorithm derived error vectors between a tele lens and a wide lens: